

APPENDIX A

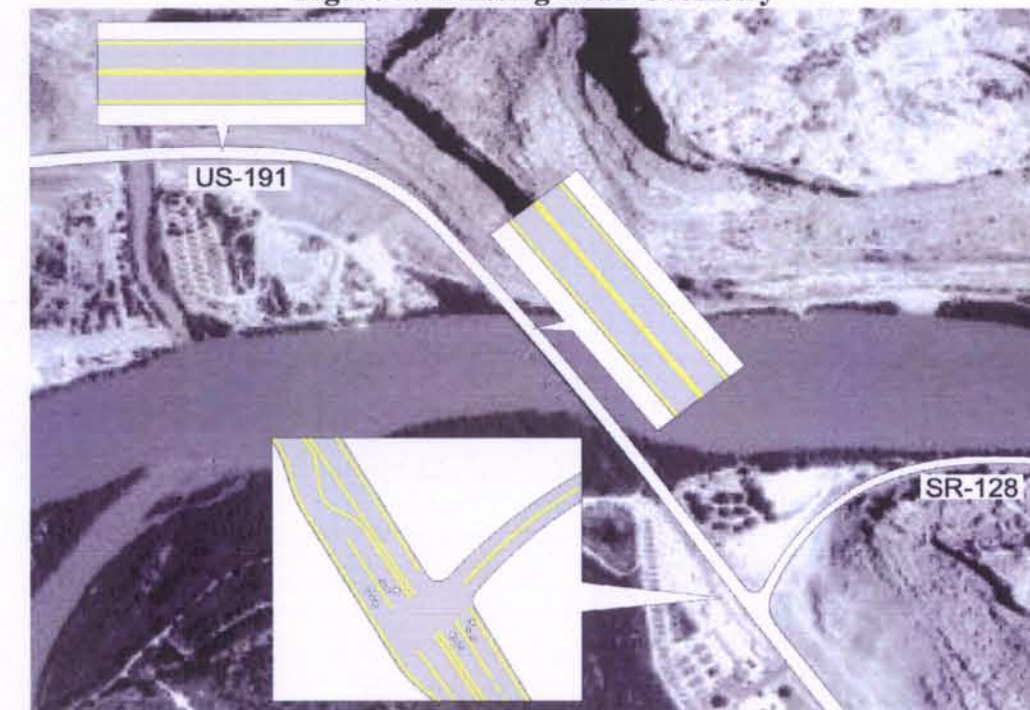
Colorado River Bridge, US-191 Traffic Report

1. Background

US-191 serves interstate traffic from Utah to New Mexico. The section south of I-70 through Moab Canyon, Moab City, and San Juan County has seen significant growth in recent years. The road is generally a two-lane rural arterial which widens to four lanes and acts as an urban main street through the City of Moab. A project is underway to reconstruct this section of road in Moab and make small improvements to landscaping, turn pockets, and sidewalks. North of Moab City an Environmental Assessment has been completed and construction has begun to widen US-191 through Moab Canyon, generally from SR-279 (Potash Road) up to SR-313 (Dead Horse Point turn-off).

A small section of road exists north of 400 North in Moab to Arches National Park that is currently two lanes and will present a traffic bottleneck after the completion of improvements in Moab Canyon. This bottleneck section is approximately 3.5 miles long and includes a crossing of the Colorado River. The Colorado River Bridge is a narrow (26 feet wide), two-lane bridge with no pedestrian or bicycle facilities. Figure 1 shows the existing geometry of the road in the general vicinity of the bridge. This section of road represents a transition from the rural 50 mph speed limit north of the bridge to a 35 mph speed limit south of 400 North. The speed limit across the bridge and through this section of US-191 is 45 mph. The need to reconstruct and/or improve the function and structural sufficiency of the bridge is the focus of the Colorado River Bridge Study. This report is intended to identify traffic flow and cross section related issues of the bridge and adjacent road sections.

Figure 1: Existing Road Geometry



2. Issues

There is a variety of traffic-related issues with respect to the Colorado River Bridge on US-191. From a pure traffic flow standpoint there is a clear argument that the existing two-lane section of road be widened to four lanes in order to match the cross-sections both north and south. Further, since bridge structures are typically designed to last at least 50 years, well beyond the 20-30 year design life of a road, consideration of a wider bridge cross-section is also important. At a minimum, consideration must be given to widening the bridge in order to serve four lanes of traffic and some consideration should be given to the costs and benefits of providing even greater capacity that might be necessary to serve traffic growth beyond a 20 year period.

Beyond motor vehicle travel, the Moab area attracts and supports an active group of pedestrians and cyclists. Grand County and Moab City have been working to develop a parallel structure to support non-motorized travel across the Colorado River. The needs for non-motorized travel should be anticipated in the cross-section of the bridge and may be supported by either two separate structures or a single larger structure. Presently, the bridge is generally on the outskirts of town and would be used by more avid and skilled cyclists, but consideration should also be given to the growth plans of the City and County in order to anticipate the needs of other recreation groups.

A growing concern in the Moab area is the increase in traffic, particularly truck traffic, on US-191. The highway serves a dual function in this area by providing a high-speed arterial facility as well as serving as Main Street for the downtown section of Moab. In addition to allowing vehicles to cross the Colorado River, the bridge serves as a gateway to the City as it represents the point at which the speed limit begins to decrease from the rural section to the urban. There is an inherent traffic-calming function in crossing the bridge as it marks the entrance to Moab and a visual reminder that vehicles have arrived in a different setting.

Like many small towns, Moab struggles to accommodate the dual function of a State Highway which also serves as Main Street. The development of restaurants and hotels along US-191 is owed largely to the traffic volumes that US-191 serves and the access that US-191 provides Moab. Yet, traffic and access also bring noise and safety concerns due to high speeds. The City strives to provide a pedestrian-friendly atmosphere and often sees conflict with the functions of a State Highway. For this reason, the concept of a by-pass road around the downtown has been discussed.

A by-pass road around growing cities is an issue that raises controversy in theory and emotional debate in practice. In the Moab area, the thought of a by-pass road raises social, environmental, and quality of life challenges that are well beyond the study of the Colorado River Bridge. However, the concept is raised to provide some background for the range of future operating conditions under which the Colorado River Bridge may function. For the purposes of this study, some consideration must be given to a by-pass that would serve as a second crossing of the Colorado River, or for a by-pass that allows a single crossing of the Colorado River to serve both high-speed through-traffic as well as growth in Moab.

Finally, the location of the bridge may represent some unique traffic engineering challenges due primarily to the location of major access points on either side of the structure. State Road 128 is approximately 500 feet south of the south end of the bridge. SR-128 runs northeast from US-191 and serves as the area's main access to the Colorado River and to Castle Valley, northeast of Moab. Acceleration for right turns off SR-128 to US-191 and deceleration for left turns from US-191 to SR-128 are in close proximity to the bridge and need to be reviewed and considered. Somewhat less of a concern but also a traffic consideration is the proximity of SR-279, Potash Road, which is located approximately 1.3 miles

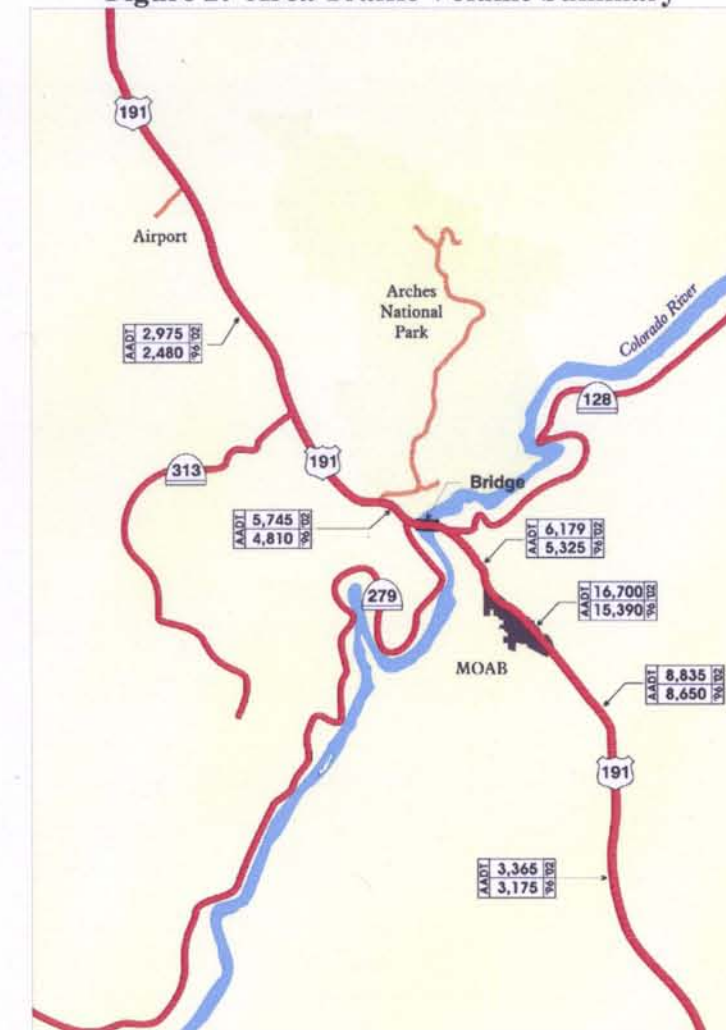
northwest of the bridge. Potash Road runs southwest of US-191 and also provides access to the Colorado River, other recreational opportunities near the river, and low volume truck access to the Potash plant.

3. Existing Conditions

A. Traffic Volumes

Existing traffic volumes increase steadily between I-70 and Moab City and then decrease south of Moab into San Juan County. Figure 2 shows traffic volumes in the area. As shown below, traffic volumes average less than 3,000 vehicles per day immediately south of I-70, increase to approximately 6,000 vehicles per day across the Colorado River, and reach over 16,000 vehicles per day through Moab before dropping to approximately 3,500 vehicles south of the city near the county line.

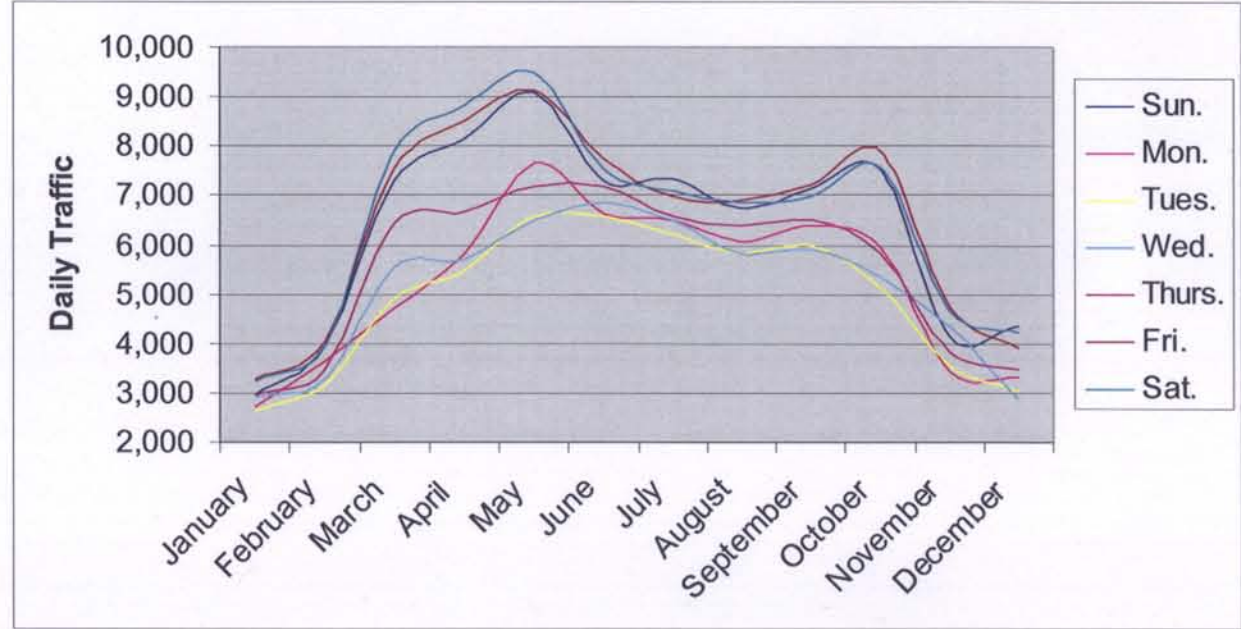
Figure 2: Area Traffic Volume Summary



i. Seasonal Traffic Variation

Due to the recreational nature of the area, seasonal variations of traffic are significant. According to the permanent count station immediately north of the bridge, ATR 421, traffic volumes fluctuate by as much as 300 percent, from the lowest volumes in December and January to the highest volumes in May. In addition, traffic volumes also vary significantly by day of the week, with Friday, Saturday, and Sunday traffic volumes higher than mid-week volumes. Figure 3 indicates 2002 traffic volumes and the variation of volumes across seasons and days of week based on count station data.

Figure 3: Daily and Monthly Traffic Fluctuation, 2002



Due to the seasonal nature of the traffic and the rural character of US-191 in this area, additional work was done in order to determine an acceptable traffic volume from which to base design characteristics. Additional factors that were considered include design hourly volume, truck percentages, and directional split. Each is discussed in more detail.

ii. Design Hourly Volume

The variations in hourly traffic are particularly important in that it is the hourly traffic flow which dictates the cross-section and other design characteristics of a road. The selection of a design hourly volume is often an issue on roads with traffic fluctuations similar to US-191. According to the AASHTO Green Book (*A Policy of Geometric Design of Highways and Streets*, 2001, American Association of State Highway and Transportation Officials, page 59), "While it would be wasteful to predicate the design on the maximum peak hour traffic that occurs during the year, the use of the average hourly traffic would result in an inadequate design." AASHTO recommends that the selection of the design hourly volume be based on a review of the hourly traffic fluctuation and should generally be based on the 30th highest hour. Figure 4 indicates the 100 highest hours of traffic in both directions in 2002.

Figure 4: 100 Highest Hours, 2002

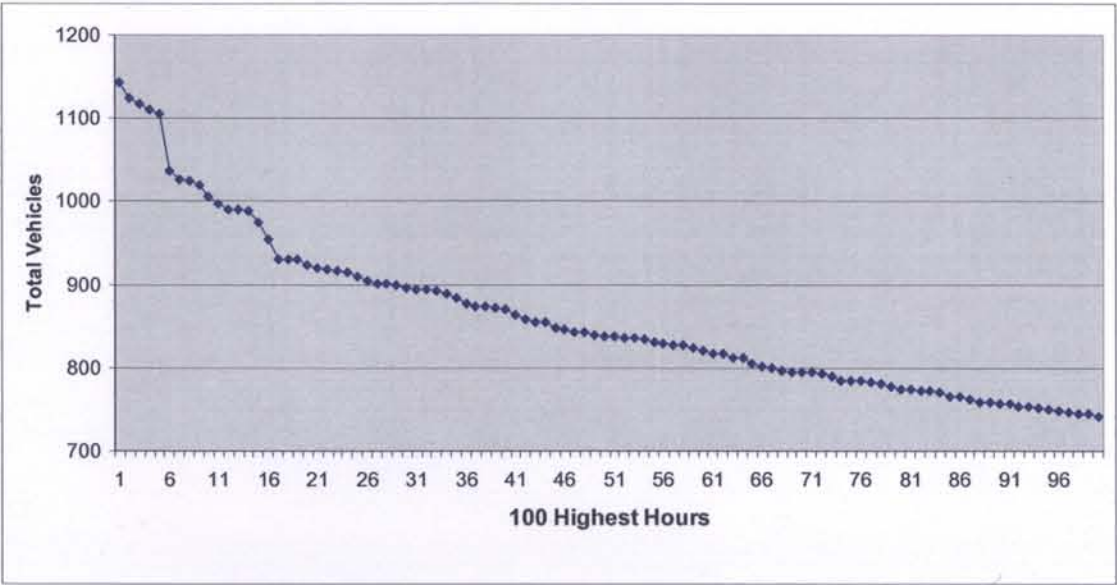
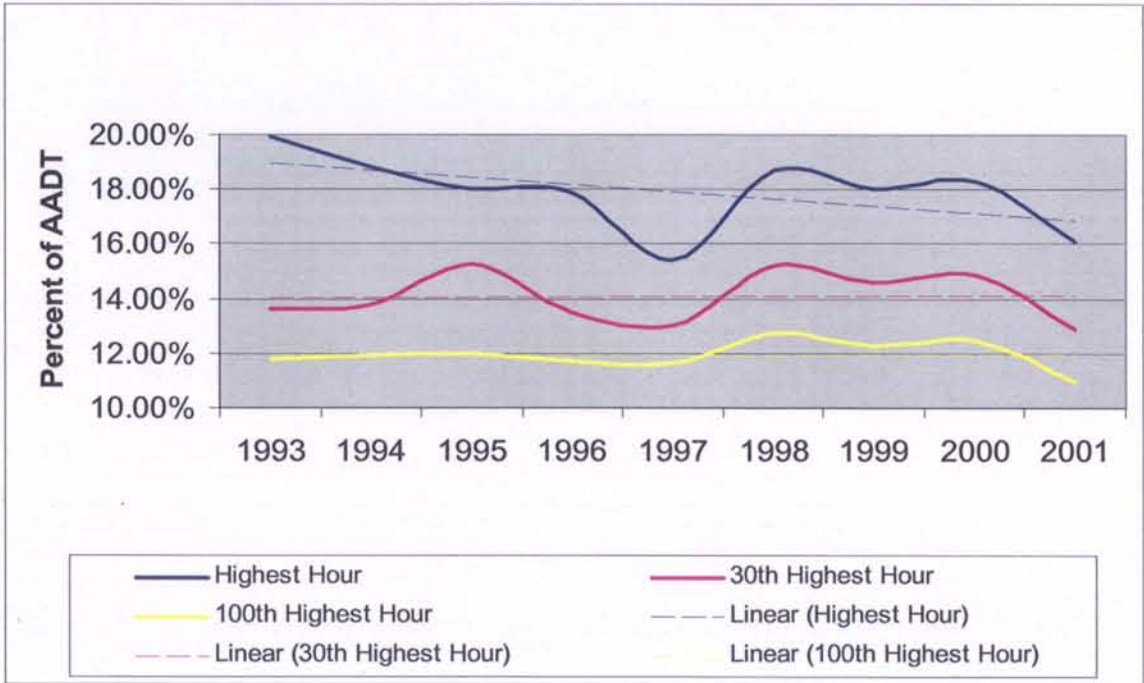


Figure 5 shows the highest, 30th highest, and 100th highest hourly traffic volumes on US-191 as well as the linear trend for each category. This graphic shows the relative stability of the thirtieth highest hour with respect to the AADT. Variations of the highest hourly volume are much larger than the 30th highest hour, an indication of the instability of the highest hour and why roads of this type are not designed to the highest hourly volume. The 100th highest hour is shown to be stable, but only differs in hourly volume from the 30th highest hour by about 2 percent of AADT. This difference is not sufficient to justify the cost savings of designing to the 100th highest hour.

Figure 5: US-191 Hourly Volumes as Percent of Daily Traffic



As discussed, the 30th highest hourly volume is quite stable over recent history and the trend indicates a percent of average annual daily traffic (AADT) of 14 percent. Further, the 30th highest hour is well within the “shoulder” of the curve for the top 100 hours, indicating that it is beyond the extremes of the highest hours and well within the high end range of more commonly expected traffic volumes, which is appropriate for design. Therefore, the design hourly volume assumed for this report is 14 percent of the AADT.

iii. **Truck Percentages**

Level of service analysis using the methods of the Highway Capacity Manual requires an estimation of the percentage of traffic which is trucks and the percentage of traffic which is recreational vehicles (RVs) for the design hour. Little data is available for the design hour and only sparse data is available for other hours of the day and year. Table 1 provides a summary of truck data available through UDOT from daily counts collected in 2002. As shown, truck percentages vary from as little as 13 percent (single and combo) trucks through Moab City to as high as 41 percent north of Arches National Park.

Table 1: 2002 Truck Percentages

Begin Mile Post	End Mile Post	Description	Both Directions			Both Directions		
			Percent Cars	Percent Single Trucks	Percent Combo Trucks	Number of Cars	Number Single Trucks	Number Combo Trucks
127.43	128.62	NORTH INCL MOAB	86.96%	4.52%	8.52%	5,609	291	550
128.62	131.27	JCT SR 128 COLORADO RIVER	63.50%	9.80%	26.70%	3,648	563	1,534
131.27	137.22	JCT ARCHES NAT MON RD	59.30%	22.82%	17.88%	1,764	679	532

Source: UDOT Planning, 2002.

Roadside survey data results also suggested that as little as five percent of the traffic was commercial vehicles, typically trucks. However, survey methods recognize a potential bias in flagging a sub-set of vehicles and the role of the flagger to determine availability of the survey crew and area, and consequently not flag subsequent trucks if the survey area was occupied one or more trucks. The Environmental Assessment for the Moab Canyon section of US-191 assumed design hourly truck percentages (truck and RV percentages were combined) consistent with average daily truck percentages of 30 percent.

Similar UDOT data from 1999 showed truck percentages varying from between ten percent in Moab to 30 percent north of Arches with 16 percent through the bridge section. For the purposes of analysis, a total truck percent of 17 percent was assumed made up of 15 percent trucks and two percent recreational vehicles. This determination was based on a reduction of the 2002 UDOT truck percentage of over 37 percent to account for likely reductions in the peak demand hours. The estimate of two percent RVs was based on similar data collected by InterPlan on US-6 and appears to be very seasonally dependent. An informal sensitivity analysis of truck and RV percentages on Level of Service revealed that the 15 percent truck and 2 percent RV assumption are reasonably accurate given available data and would not significantly alter the results given small variations in truck levels.

iv. **Directional Split**

Directional traffic volumes are highest on Friday afternoons when as much as 80 percent of the traffic is heading southbound into Moab and on Sunday mornings when traffic is heading northbound away from Moab. For this reason, directional split is an important component in determining design characteristics. Table 2 shows the data related to the 20th through 40th highest hours of traffic for 2003.

Table 2: 20th through 40th Highest Hours, 2003

Rank	Volume	Start Time	Date	Day	Directional Split SB/NB (%)
20	865	3 PM	April 26	Saturday	54/46
21	862	4 PM	April 17	Thursday	67/33
22	861	10 AM	April 19	Saturday	37/63
23	856	3 PM	May 24	Saturday	59/41
24	851	2 PM	April 20	Sunday	38/62
25	848	1 PM	April 26	Saturday	57/43
26	847	1 PM	May 24	Saturday	65/35
27	843	6 PM	April 19	Saturday	49/51
28	836	2 PM	April 19	Saturday	48/52
29	836	2 PM	May 25	Sunday	53/47
30	831	1 PM	April 18	Friday	61/39
31	830	2 PM	April 18	Friday	65/35
32	827	3 PM	April 20	Sunday	38/62
33	827	12 PM	May 26	Monday	35/65
34	822	1 PM	April 19	Saturday	52/48
35	821	3 PM	April 17	Thursday	69/31
36	818	4 PM	April 20	Sunday	40/60
37	812	11 AM	April 26	Saturday	54/46
38	810	4 PM	April 26	Saturday	54/46
39	808	1 PM	May 26	Monday	42/58
40	807	11 AM	May 25	Sunday	39/61

The average directional split over the 20th to 40th highest hours is 59 percent southbound and 41 percent northbound. A 59/41 average directional split is reasonably close to the actual 30th highest hour. This average directional split is assumed in analysis and consideration of design characteristics. Again, the Moab Canyon Environmental Assessment based the directional split on actual counts in both weekday and weekend periods. The Environmental Assessment resulted in a 59/41 weekday directional split but a higher, 68/32 weekend directional split at the SR-128 intersection.

B. **Traffic Characteristics**

i. **Traffic Survey**

As part of the analysis for the Colorado River Bridge, a traffic survey was conducted on US-191 just north of Moab from Thursday, March 25 to Saturday, March 27, 2004. Questionnaires were handed out randomly to cars traveling north on US-191. A flagger stopped vehicles randomly, about ten cars at a time, immediately after having crossed the Colorado River Bridge. The cars were pulled off the road to a small parking lot and a questionnaire was given to each vehicle stopped. One thousand questionnaires were distributed during the three-day survey. In the case that a vehicle was stopped more than once, they were not given a second survey.

Of the 1000 surveys distributed, 264 responses were received by April 28, 2004. In statistical terms, 264 responses give a 95 percent confidence level and a six percent confidence interval. These parameters indicate that there is 95 percent confidence that survey results would reflect the same answers, +/- six percent, if all the cars on the highway had answered the questions.

Questionnaire

The questionnaires were postcards with return postage paid in order to minimize traveler inconvenience and increase survey return rates. Travelers were asked to complete the questionnaire and mail it to InterPlan within one week of receiving it. The questionnaire served several purposes:

- To establish the relationship between Moab and the amount of bridge traffic,
- To determine trip purpose for the purpose of traffic forecasting,
- To measure the number of travelers and vehicles crossing the bridge and to compare the results again various crossing options, and
- To measure traffic services that are found in the city of Moab that might be lacking and/or demanded with the implementation of a by-pass road.

Questions were developed with these purposes in mind and so that data would be collectable and easily managed. The seven questions were developed jointly by InterPlan and UDOT. A copy of the questionnaire is shown on the following page.

Errors

Although effort was made to minimize errors, there were several possibilities for error which should be openly acknowledged. The most common error was human error. Human error could occur in several ways.

- First, many of the surveys received had responses scratched out and other responses entered or questions left with no response. There were a few questionnaires returned blank.
- Second, the process of entering survey responses into spreadsheet format could be a small source of errors. Quality control efforts double checked data entry to eliminate this possible error.
- Third, survey responses that were incoherent or illogical were a source of error as well.

There were also other possible errors or biases in the survey process. While there was no set pattern for the flagger to stop vehicles (i.e. every tenth car) it was not perfectly random. Only cars traveling northbound along US-191 were stopped. Ideally, cars traveling in both directions would have been stopped and surveyed, but that was not done due to safety issues. There are also biases for the time of day, the days of the week, and the time of the year that the survey was conducted. These errors were considered, but it was concluded that these small survey biases would be acceptable for traffic projection purposes.

Figure 6: Survey Questionnaire

Help us improve YOUR transportation system!

Please answer these questions about today's trip and mail this postcard **WITHIN ONE WEEK**. Postage has been paid. Thank you for your help. Please call 801-307-3400 if you have questions about this survey.

- Please indicate what kind of vehicle you are driving:

<input type="checkbox"/> Private vehicle	<input type="checkbox"/> Bus
<input type="checkbox"/> Commercial vehicle	<input type="checkbox"/> Other (specify) _____
<input type="checkbox"/> Multi-axle truck (semi)	
- What city or town was your point of origin?

- What city or town is your destination?

- What is the purpose of this trip? (check all that apply)

<input type="checkbox"/> Working	<input type="checkbox"/> Eating
<input type="checkbox"/> Mountain biking	<input type="checkbox"/> Overnight Stay
<input type="checkbox"/> Shopping	<input type="checkbox"/> Hiking
<input type="checkbox"/> River rafting	<input type="checkbox"/> Gas/rest stop
<input type="checkbox"/> Visiting Arches National Park	<input type="checkbox"/> Home
<input type="checkbox"/> Visiting other National or State Parks	<input type="checkbox"/> Other _____
- What is the purpose of your driving through Moab? (check all that apply)

<input type="checkbox"/> I/we are not driving through Moab	<input type="checkbox"/> Food
<input type="checkbox"/> Just passing through on SR-191	<input type="checkbox"/> Overnight stay
<input type="checkbox"/> Gas	<input type="checkbox"/> Other
- In what city and state do you live?

- Circle the number of people in your vehicle: 1 2 3 4 5+

Survey Results

The data received from the survey yielded several interesting results. The first question on the survey asked respondents to indicate what kind of vehicle they were driving. Responses to this question are listed in Table 3. The vast majority of vehicles that cross the Colorado River Bridge on US-191 are private vehicles, including cars, trucks, and sport utility vehicles. Several vehicles were listed as “other”; these include mostly recreational vehicles. Larger vehicles such as buses and commercial semi-trucks represent a smaller amount, about 4.6 percent, of the traffic surveyed. It is significant that only 4.6 percent of the traffic surveyed were commercial vehicles. According to cross-tab survey results, the vast majority of these vehicles are not traveling to, but rather through the city of Moab. These commercial vehicles would more likely use a by-pass road around the city if one were to be built.

Table 3: Type of Vehicle

What kind of vehicle are you driving?	Responses	%
Private Vehicle	245	93%
Commercial Vehicle	12	5%
Bus	0	0%
Other	6	2%
Total	263	

The second question on the survey asked “what city or town was your point of origin?” and the third was “what city or town is your destination?” These questions were intended to help in determining where vehicle trips that cross the bridge begin and end. The responses for origin and destination were divided into eight categories, shown with the results of the origin/destination question in Table 4. Responses to the survey varied a great deal in terms of trip origin and destination, with many responses being various parts of the United States. However, of 264 vehicles surveyed, 182 listed Moab as either their origin or their destination and many indicated Moab as both. Figure 7 graphically represents origin and destination results by vehicle number and Figures 8 and 9 indicate geographically the origin and destination of vehicles crossing the Colorado River Bridge.

Table 4: Origin and Destination

What city or town is your....	Origin?	Destination?
Moab	79	134
Wasatch Front	37	33
Arches NP	2	15
Utah NW of bridge	8	6
Utah SE of bridge	8	4
Colorado	62	30
New Mexico	12	2
Other	53	38
Total	261	262

Figure 7: Origin and Destination

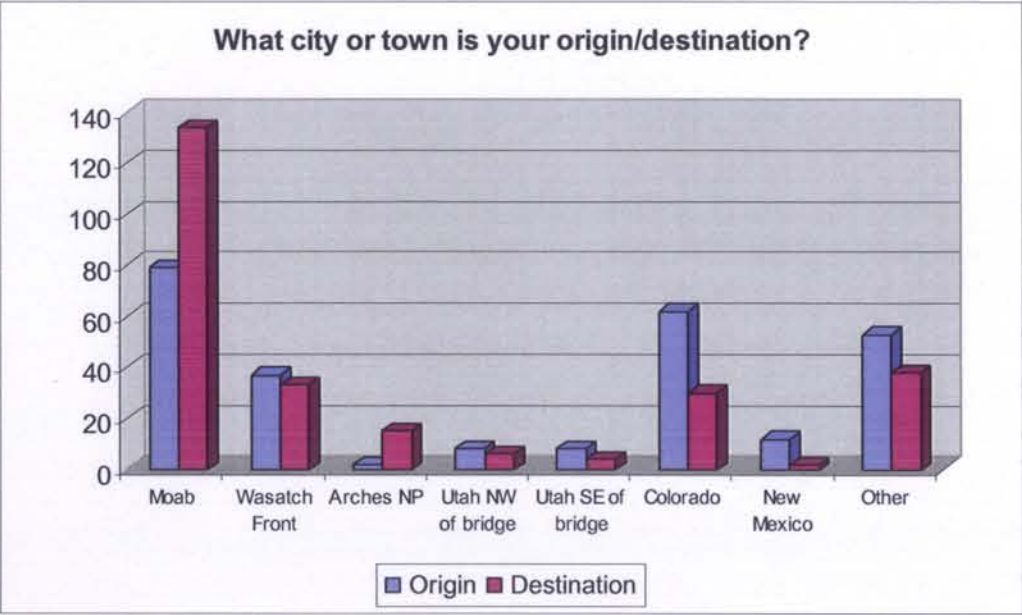


Figure 8: Origin of Trips Crossing Colorado River

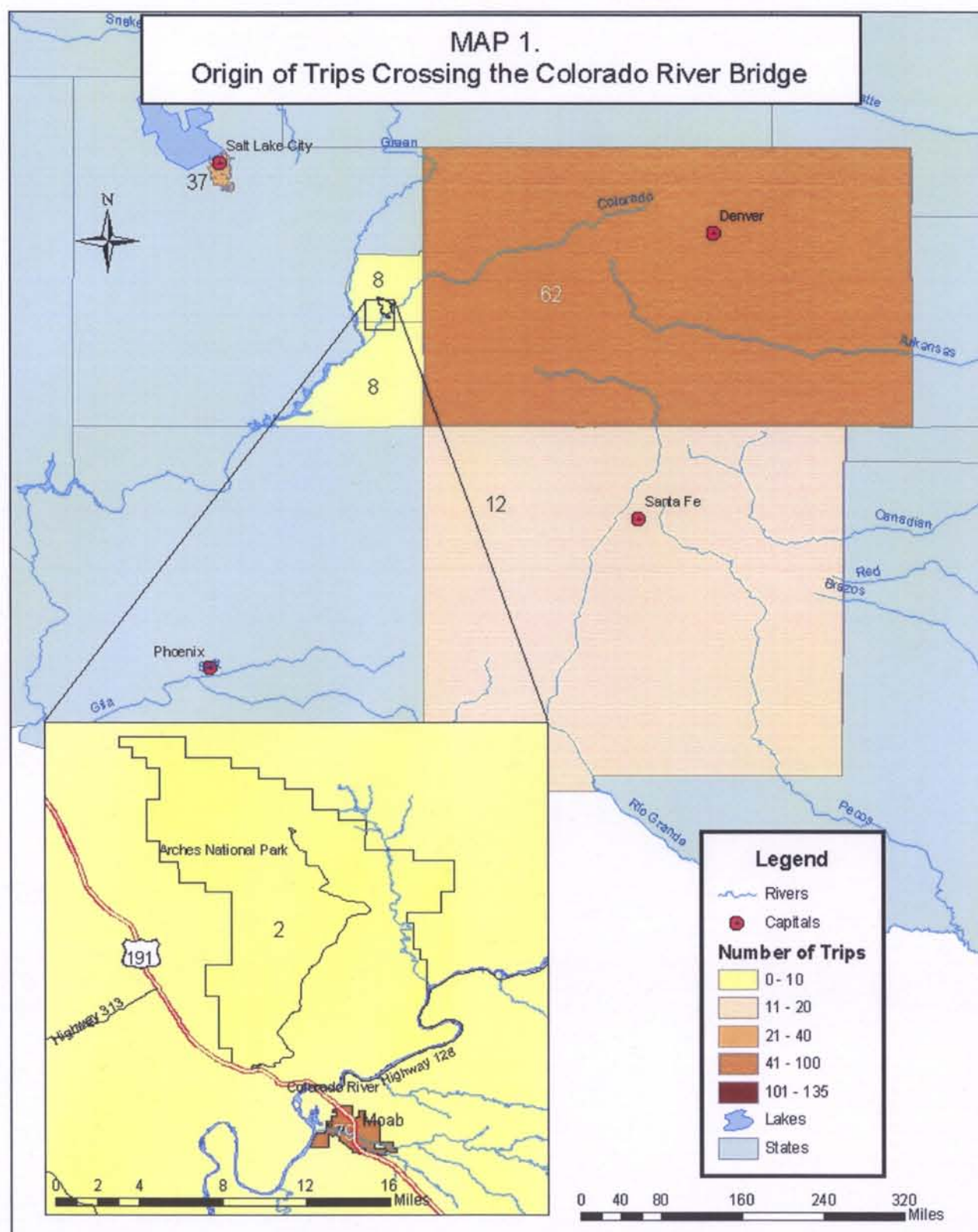
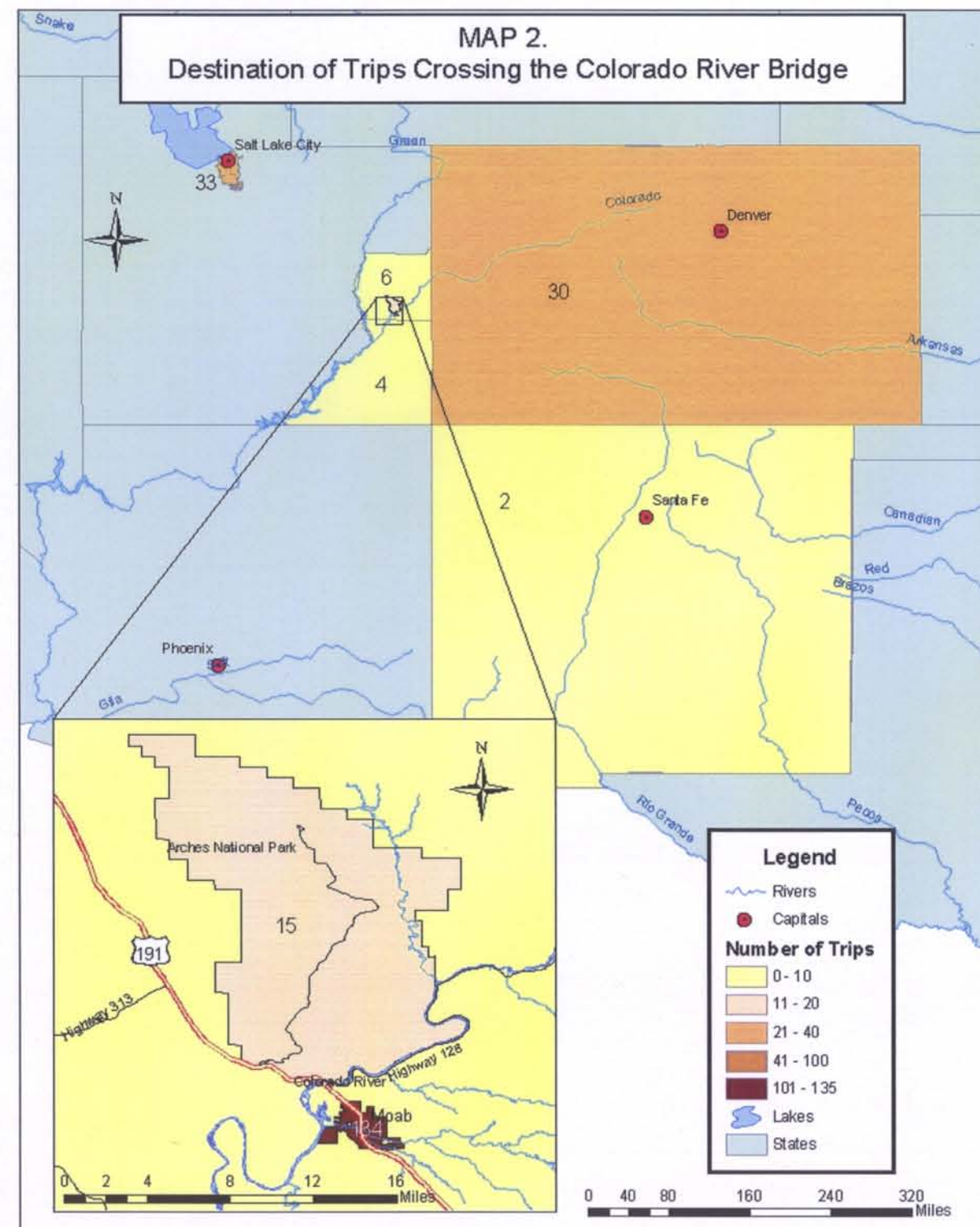


Figure 9: Destination of Trips Crossing Colorado River

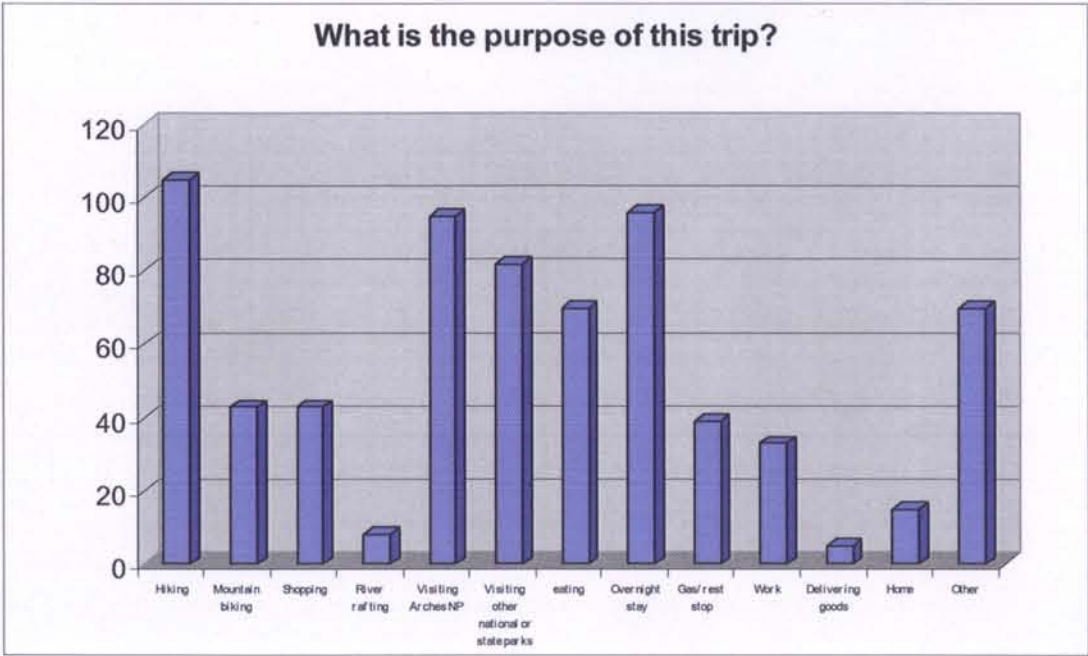


The next survey question was regarding trip purpose. This question allowed participants to choose as many answers as applied from a list of responses. The trip purposes and responses are shown in Table 4. Responses are displayed graphically in Figure 10.

Table 4: Trip Purpose

What is the purpose of this trip?	Responses
Hiking	105
Mountain biking	43
Shopping	43
River rafting	8
Visiting Arches NP	95
Visiting other national or state parks	82
Eating	70
Overnight stay	96
Gas/rest stop	39
Work	33
Delivering goods	5
Home	15
Other	70
Total	704

Figure 10: Trip Purpose



From survey responses to the trip purpose question, most of the bridge traffic to Moab is for the purpose of tourism and recreation, and not for business or work. The four most common trip purposes given were hiking, overnight stay, visiting Arches National Park, and visiting other national or state parks. The fewest responses were given for delivering goods, river rafting, and home. River rafting is a popular recreational activity in the area, but March is not rafting season. Only 33 travelers were crossing the bridge for work purposes, most of these responses included semi-trailers and commercial vehicles.

The fifth survey question was “what is the purpose of your driving through Moab?” Again, this question listed several possible options and asked the travelers to check all that applied. This question was designed to get an idea of if people were traveling to/from Moab and if so, what types of services they were utilizing while there. Survey responses are shown in Table 5. Overnight stay had the most responses with the second most common reason being “other.”

Table 5: Purpose of Driving Through Moab

What is the purpose of your driving through Moab?	Responses
I/we are not driving through Moab	44
Just passing through on US-191	55
Gas	44
Food	51
Overnight stay	113
Other	63
Total	370

Only 44 vehicles of 264 (17 percent) surveyed, indicated that they are not driving through Moab. That indicates that approximately 83 percent of the vehicles that travel on US-191 across the Colorado River Bridge are passing through or using services in the city of Moab. This shows that the services in Moab are directly related to the number of travelers crossing the Colorado River Bridge. In interpreting the results of this survey questions, it is important to remember that respondents could choose more than one response, and so results can not be added together.

The survey’s sixth question asked respondents where they lived. Responses to this question were categorized the same way that questions regarding origin and destination were categorized. Responses are shown in Table 6.

Table 6: Place of Residence

In what city and state do you live?	Responses
Moab	46
Wasatch Front	40
Utah NW of Bridge	4
Utah SE of Bridge	7
Colorado	73
New Mexico	12
Other	77
Total	259

The State of Colorado was the highest response category with 73 respondents crossing the Colorado River. This is not surprising as Grand Junction, Colorado is the closest urban area to the Moab area, with a population ten times greater than Moab. The second greatest response was Moab. The Wasatch Front is the third largest group, and the majority of the travelers surveyed live outside the State of Utah, about 62 percent.

The seventh and final question asked the travelers to indicate the number of people in their vehicle. Vehicle occupancy can be an indication of the viability of public transportation services, shuttles, buses, etc. Table 7 shows the number of vehicles at each occupancy level and the total number of people crossing the Colorado River Bridge.

Table 7: Vehicle Occupancy

Vehicle Occupancy	Number of Vehicles	Number of People
1	52	52
2	119	238
3	34	102
4	33	132
5+	28	140+
Total	266	664+

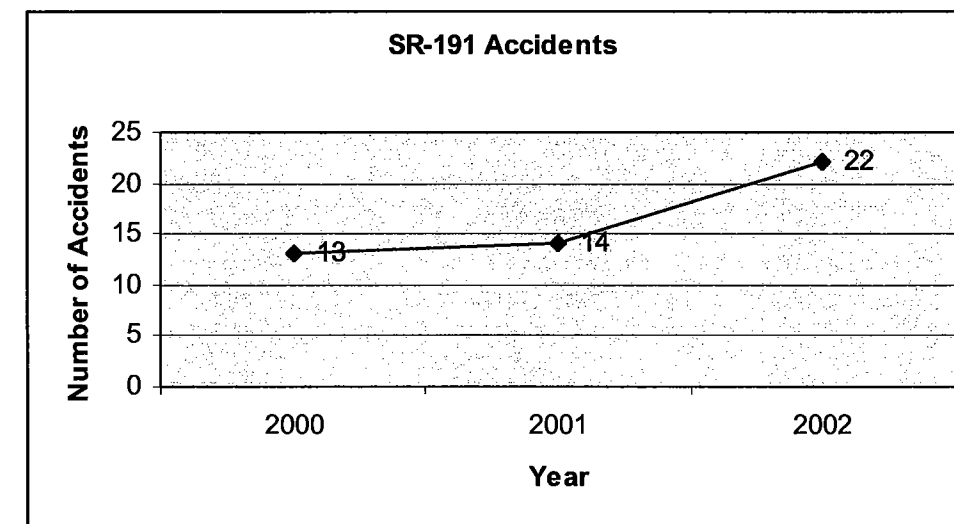
Overall, there is a rate of 2.5 persons per vehicle. This number cannot be exact because 28 questionnaires were marked 5+ people in the vehicle, which could indicate 5, 6, 7, or more in those vehicles. A rate of 2.5 persons per vehicle indicates that the vast majority of vehicles were carrying two or more people. Only 20 percent of vehicles had only one person. By comparison, urban roadways typically produce average vehicle occupancies of approximately 1.5.

C. Safety

Safety is of great importance and is a particular concern on US-191 as the road serves as both an important State Highway and a community Main Street. The apparent clash of these two roadway objectives has been a growing concern for the City of Moab and Grand County. Bridges and roads should be constructed and maintained to provide a transportation system that meets customer expectations in terms of safety and, where possible, to continuously reduce accidents and improve safety. Accident information is based on UDOT accident data over the three year period from 2000 to 2002.

The project area has relatively few accidents, but the numbers are increasing. In 2000 there were 13 accidents on US-191 from milepost 126 to 132, which begins at approximately the entrance to Arches National Park, includes the Colorado River Bridge, and terminates in Moab. Along that same stretch of road there were 14 accidents in 2001. That number increased by 57 percent in 2002 to 22 accidents. There were only 49 accidents during the three-year period from 2000 to 2002. Figure 11 shows the number of accidents by year.

Figure 11: Number of Accidents



The number of accidents has increased as has the accident rate. The accident rate is a standard measure used by UDOT to determine the frequency of accidents along roads. UDOT defines the accident rate consistently with other states as the number of accidents per one million vehicle miles. The rate is calculated by dividing the number of accidents by the number of vehicles that drove that road segment, multiplied by the length of the segment, divided by one million. Table 8 shows the accidents rates for 2000, 2001, and 2002.

Table 8: Accident Rates and Severity

	2000	2001	2002
Number of Accidents	13	14	22
Accident Rate	0.89	0.96	1.49
Severity	1.38	1.71	1.77

The accident rate increased to 1.49 accidents per million vehicle miles in 2002, which is still lower than the UDOT expected accident rate of 1.96 based on similar roads in Utah. For the three-year period from 2000 to 2002, the average accident rate was 1.13 accidents per million vehicle miles, while the expected rate for this period was 1.96.

Accident severity is measured by UDOT on a scale of 1-5, with the following definitions:

- 1 = No Injury
- 2 = Possible Injury
- 3 = Bruises, Abrasions
- 4 = Broken bones, Bleeding
- 5 = Fatality

The accidents that did occur were not severe and there were no reported fatalities in the study corridor. A weighted average of accidents by severity is calculated and reported as the severity rate. The reported severity rate is not standard between states, but represents a commonly reported value by UDOT and can be used to evaluate the severity of accidents. According to UDOT, the severity rate of this section of US-191 is 1.69, slightly below the expected severity rate for similar facilities. The severity level for accidents along this segment of US-191 has been consistently between 1 (no injury) and 2 (possible injury). Most of the accidents that do occur along this segment of US-191 do not result in injuries.

According to the UDOT’s Draft Operational Safety Report (see Appendix), there were 49 accidents along the US-191 road segment from 2000 to 2002. Of those, the largest number of accidents, 21 (42.9 percent), were single vehicle accidents. Most of the single vehicle accidents were wild animal related. Table 9 lists single vehicle accident type, numbers and percentages.

Table 9: Single Vehicle Accident Type

Accident Type	Number	Percent of Single Vehicle Accidents
Wild Animal Related	12	57.1%
Overtuned in Roadway	2	9.5%
Other Object	1	4.8%
Ran off Road	5	23.8%
Bicycle Related	1	4.8%
Total	21	100.0%

All of the wild animal related accidents that occurred on US-191 happened between mileposts 127 and 128. Environmental analysis should review the site-specific nature of animal-related crashes and mitigation, such as animal fencing. There were also seven rear-end accidents in this segment between 2000 and 2002. Most of these accidents occurred between 100 North and 400 North Streets in Moab. A left turn lane in this urban section should be considered to eliminate turn conflicts and reduce accidents.

D. Existing Level of Service

US-191 is categorized as a Class I two-lane highway. According to HCM 2000, two-lane highways are divided into two classes for analysis purposes:

- Class I – These are two-lane highways on which motorists expect to travel at relatively high speeds. Two-lane highways that are major intercity routes, primary arterials connecting major traffic generators, daily commuter routes, or primary links in state or national highway networks generally are assigned to Class I. Class I facilities most often serve long-distance trips or provide connecting links between facilities that serve long-distance trips.
- Class II – These are two-lane highways on which motorists do not necessarily expect to travel at high speeds. Two-lane highways that function as access routes to Class I facilities, serve as scenic or recreational routes that are not primary arterials, or pass through rugged terrain generally are assigned to Class II. Class II facilities most often serve relatively short trips, the beginning and ending portions of longer trips, or trips for which sightseeing plays a significant role.

Level of service for two-lane highways is determined by the percent time spent following and the average travel speed. Thresholds for each of these factors by level of service are shown in Table 10.

Table 10: Level of Service Criteria for Class I Two-lane Highways

Level of Service	Percent Time Spent Following	Average Travel Speed (mph)
A	<35 %	>55
B	35-50	50-55
C	50-65	45-50
D	65-80	40-45
E	>80	<40
F	Whenever flow rate exceeds segment capacity	

Because the speed limit on US-191 in this area is 45 mph, levels of service A, B, and C are not technically achievable. However, analysis focused on the percent of time following criteria in order to report what the level of service would be if speed limits allowed. HCS analysis performed for this segment using 30th highest hourly volume and assuming 15 percent trucks, two percent recreational vehicles, and 59 percent southbound and 41 percent northbound traffic gives an existing level of service of D. The UDOT standard level of service in non-urban areas is C while AASHTO recommends that rural highways should be designed to level of service B. Regardless of the exact standard, it is clear that even under existing conditions, the traffic levels are creating an inconvenience and delay to motorists due to inadequate capacity.

4. Future Traffic Conditions

In order to gain a better understanding of future traffic conditions, considerable attention was given to developing traffic projections which attempt to accurately represent the economic and recreational character of the area. Truck traffic is also of particular importance in the design of rural roadways, and a better understanding is needed of the factors that may affect truck traffic in the future. A more detailed discussion of these and other factors related to projected increases in traffic is discussed below.

A. Traffic Volumes

Traffic across the Colorado River Bridge has grown steadily. Between 1993 and 2002, traffic increased at an average annual rate of over 2.6 percent. Traffic growth north of the bridge was much stronger in percentage terms due to the significantly lower volumes north of SR-313 which serves Dead Horse Point State Park. Recent and on-going studies of the adjacent sections of US-191 estimated a three percent average annual growth rate for the widening of Moab Canyon (Sear Brown, 2001) and a one percent average annual growth rate for the reconstruction of Moab Main Street (Michael Baker, 2004) in order to support the design of each of these separate projects.

As part of the Colorado River Bridge study, traffic projections were estimated independently of those done by other studies. InterPlan’s was a multi-step process that incorporated the results of the survey discussed earlier in this report, 2002 AADT as reported in UDOT’s *Traffic on Utah Highways*, as well as information related to historic visitor numbers from Arches National Park and Deadhorse Point State Park.

First, the 2002 AADT was broken down by residence of the driver, based the same proportions observed from traffic survey results. Six categories were used:

- Moab
- Wasatch Front Counties
- Other Utah Counties
- Colorado
- New Mexico
- Other areas outside Utah

Next, all existing vehicle trips were assigned a trip purpose: work, recreational, or other. Trip purpose was attributed to each of the “residence” categories based on statistical analysis of the residence categories and what respondents identified as their trip purpose on the survey. “Work trips” were estimated by summing those that identified their trip purpose as work for each of the six residence categories. This process was done for recreational trips and other trips as well, to existing AADT was divided by both trip purpose and by place of residence.

These categories were then used to project future traffic volumes. Work trips were “grown” by the projected growth of employment for each of the geographic components. For example, vehicles that were from Colorado were increased by the same rate that the State of Colorado projects for employment growth between 2002 and 2030. Similarly, vehicles from the Wasatch Front were increased by the same rate that Wasatch Front Counties are expected to increase employment between 2002 and 2030. This was done for each residence category.

Recreation trips were grown based on information taken from the master transportation planning process currently being conducted for Arches National Park. As part of this process, visitor numbers were projected to the year 2030. Historic visitor trends were observed: from 1982 to 1992, annual visits grew by 10 percent; from 1992 to 2002, about 1.9 percent growth per year. These annual increases were not believed to be indicative of future growth, the earlier decade was considered too aggressive while the latter decade too conservative. A straight trend line from 1982 to 2002 gives an annual growth of 6.4 percent, also believed to be higher growth than should be expected in coming decades. Project consultants for Arches National Park assumed 3.11 percent average annual growth between 2004 and 2030 yielding an overall increase of 121.7 percent. Recreational trips on US-191 were increased by this rate to

determine 2030 recreational trips. “Other” trips were increased based on the projected population growth in each area of residence, similar to work trips and employment growth.

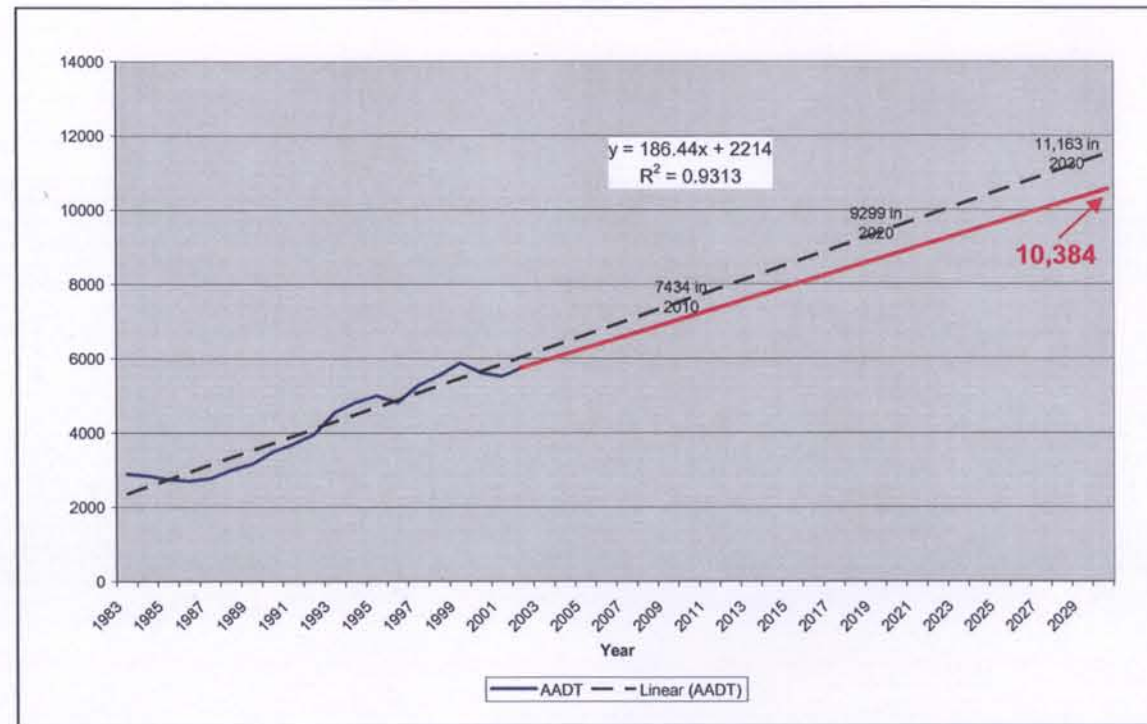
All of the components of 2030 traffic volume projections are shown in Table 11. Traffic volumes on US-191 in 2030 are project to be 10,384 vehicles.

Table 11: 2030 Traffic Volumes on US-191

		2000 Volume	Trip Purpose	2000 Trips	2030 Trips
Total AADTs in Corridor Segment (2002)		5,745	Work Trips	941	1,329
Utah Vehicles	37.5%	2,154	Recreation Trips	3,039	6,737
Colorado Vehicles	45.1%	1,619	Other Trips	1,697	2,318
New Mexico Vehicles	7.4%	266	Total Trips	5,678	10,384
Other Vehicles	47.5%	1,706			
Out of State Vehicles	62.5%	3,591			
Total Utah Vehicles		2,154			
Moab	47.4%	1,021			
Wasatch Front Counties	41.2%	888			
All other Utah Counties	11.3%	243			

Projections of traffic volumes are shown in Figure 12. Year 2030 volumes based on a linear projection of the past 20 years revealed an estimate of 11,163 vehicles per day in the year 2030. However, similar to park visitor projections, it was assumed that a straight-line projection for vehicles was too aggressive since recreational trips are generally expected to grow at lower rates in the future than they have in the past. The disaggregate method of projecting traffic and the resulting year 2030 volume of 10,384 were assumed in future traffic analysis.

Figure 12: Traffic Volume Projections



i. Seasonal Traffic Variation

Southeastern Utah, with its national and state parks and national recreation areas, is a tourist destination for people from all over the world. The tourism character of the area, and thus the seasonal nature of the tourism industry and related traffic on US-191, is expected to continue into the future.

ii. Design Hourly Volume

A detailed discussion of Design Hourly Volume is given in "Existing Conditions." As shown in that discussion, the assumption of 14 percent of AADT for the design hourly volume has proven stable over recent history and is anticipated to remain relatively constant in the future.

iii. Truck Percentages

Future truck percentages are difficult to determine because the nature of goods delivery and technology is uncertain. The determination of truck percentages under existing conditions was based on daily volumes given by UDOT. While the percentage of truck traffic might vary somewhat over time, for the purposes of this analysis, it is sufficient to assume it is constant at 15 percent in the future. Recreational vehicles are assumed to remain constant at two percent into the future as well. Although it is difficult to anticipate the design hour in the future, traffic counts taken over the Easter weekend in March or April might confirm the assumptions used for truck percentages prior to a major highway investment, but the truck percentages presented in this analysis are adequate for planning purposes and represent the best available data.

iv. Directional split

Future directional split is assumed to be the same as that of existing conditions, 59 percent and 41 percent. Since the grade in this area is relatively flat, and the direction of traffic reverses at various hours, it is not pertinent to identify which direction corresponds to each directional percentage. The directional split is based on the assumption that traffic patterns are unlikely to change drastically in the future unless major

shifts were to occur such as Moab becoming a large employment center or Arches National Park ceasing to exist. As these events are highly unlikely, directional split is held constant for future year analysis.

B. Safety

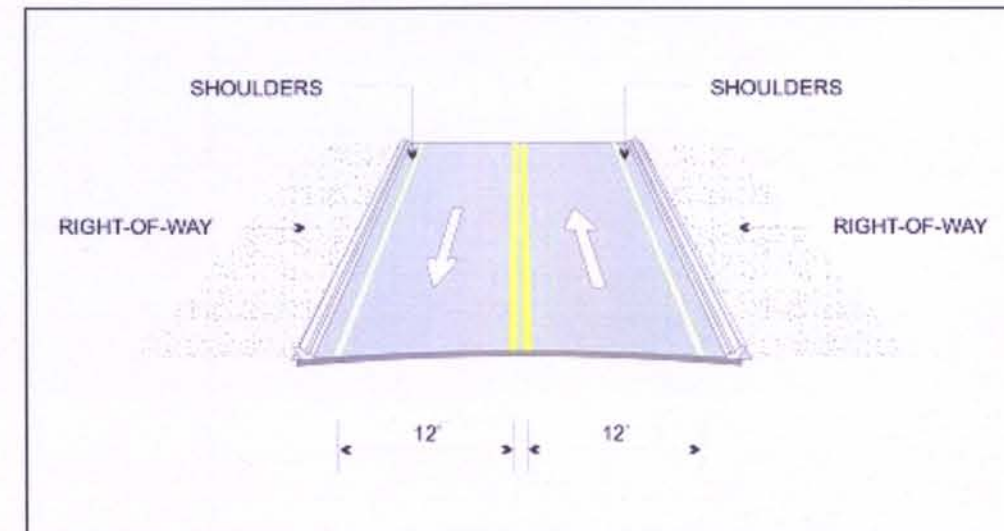
With an increase in traffic volume, an increase in accident numbers would be expected as well. However, due to the many factors which affect safety, including traffic volume and density, road geometry, weather, etc., it is difficult to project future accident numbers. Intersections and driveways are always a safety concern and, in vicinity of the bridge, there are few driveways with low traffic but poor sight distance as well as the SR-128 intersection.

With respect to the bridge, future safety concerns need to be considered carefully, mainly in terms of bicyclists and pedestrians, as well as possible southbound left-turn queues from US-191 onto SR-128. Sufficient shoulder width and turn pocket length are discussed in more detail later in this report.

C. Future Level of Service

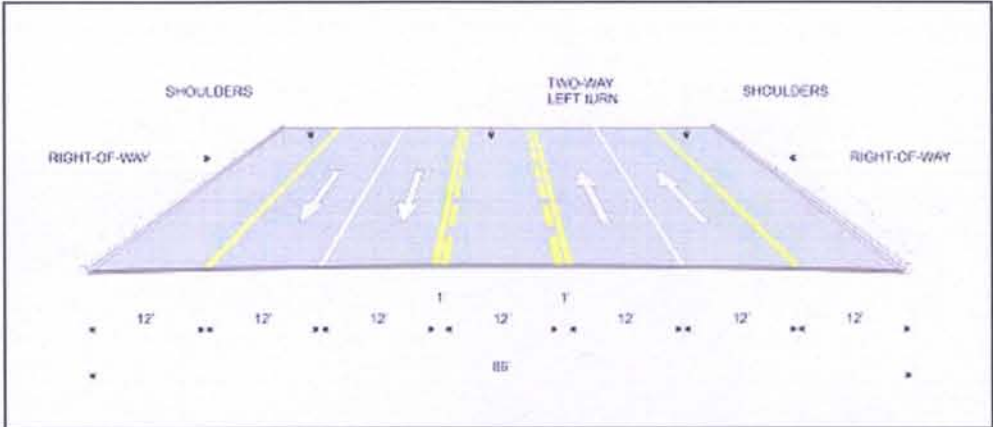
HCS analysis was performed to calculate maximum traffic volumes for a no-build alternative, an improved bridge geometry alternative, and a four-lane alternative with related level of service. The no-build alternative assumes that the bridge would remain a two-lane bridge with no pedestrian or bicycle facilities and substandard shoulders. This section of road represents a transition from the 50 mph speed limit to a 35 mph speed limit. The speed limit across the bridge and through this section of US-191 would remain 45 mph with shoulders approximately 2-3 feet wide. The no build cross-section is shown in Figure 13.

Figure 13: No Build Alternative Cross-Section



The four-lane alternative assumes that US-191 and the bridge would be reconstructed to four lanes, with 12-foot shoulders provided for emergency stops and pedestrians and bicyclists. Assumptions for this alternative are shown in Figure 14.

Figure 14: Four-Lane Alternative Cross-Section



This figure represents the recommended cross-section south of the bridge. See Figure 15 for recommended cross-section on bridge and north of bridge.

Table 12 shows maximum traffic volumes for the no-build, improved bridge geometry, and four-lane alternatives in order to maintain each level of service.

Table 12: Maximum Hourly Traffic Volume Capacity By Alternative and Level of Service

Alternative	LOS A	LOS B	LOS C	LOS D	LOS E	LOS F
2 lanes – no-build	N/A	N/A	< 691	691-1,281	1,282 – 2,461	> 2,461
2 lanes – improved	N/A	N/A	< 695	695-1,287	1,288 – 2,497	> 2,497
4 lanes	< 1,371	1,372-2,241	2,242-3,237	3,238-4,298	4,299-5,253	> 5,253

N/A = not achievable for the given condition as speed limit needs to be at least 50 mph for LOS A&B and present volumes exceed those for LOS C. Level of Service is F when the flow rate exceeds the segment capacity of 1700 pc/h (highest directional split) as calculated based on other assumptions described.

Given the design hourly volume previously determined (14 percent of 10,384 2030 AADT = 1,454 vehicles/hour), a four-lane cross-section on the Colorado River Bridge is necessary to maintain an acceptable level of service in 2030. Given the parameters defined in Table 12, the future level of service is E for both of the two-lane alternatives. A four-lane cross-section would result in a future level of service B and provide for significant flexibility and growth of traffic to a bridge service life well beyond the design year 2030.

For the US-191 and SR-128 intersection, analysis of future level of service was performed. Intersection level of service is defined as how well an intersection operates based on levels A through F with A representing the best operating conditions and level F the worst. Typically, LOS C or D service flow rates are used as minimally acceptable standards in order to maintain traffic operations. The analysis was performed using Synchro, a traffic engineering software. Synchro methods are consistent with the methods and procedures of the Highway Capacity Manual to calculate vehicle delay on the road network. Table 13 illustrates LOS definitions for stop-controlled intersections on suburban arterial streets as defined by the Transportation Research Board in the Highway Capacity Manual.

Table 13: Level of Service Criteria for Two-way, Stop Controlled Intersections

Level of Service	Average Control delay (s/veh.)
A	0 – 10
B	> 10 – 15
C	> 15 – 25
D	> 25- 35
E	> 35 – 50
F	> 50

Future intersection turn movements are shown in Table 14. Analysis indicates that operational level of service for the US-191/SR-128 intersection under assumed future traffic conditions, including a four-lane cross-section on US-191 will be A. The UDOT Draft Operational Safety Report indicated no spike in traffic accidents at this intersection, and given the expected level of service, no future accident problems are anticipated

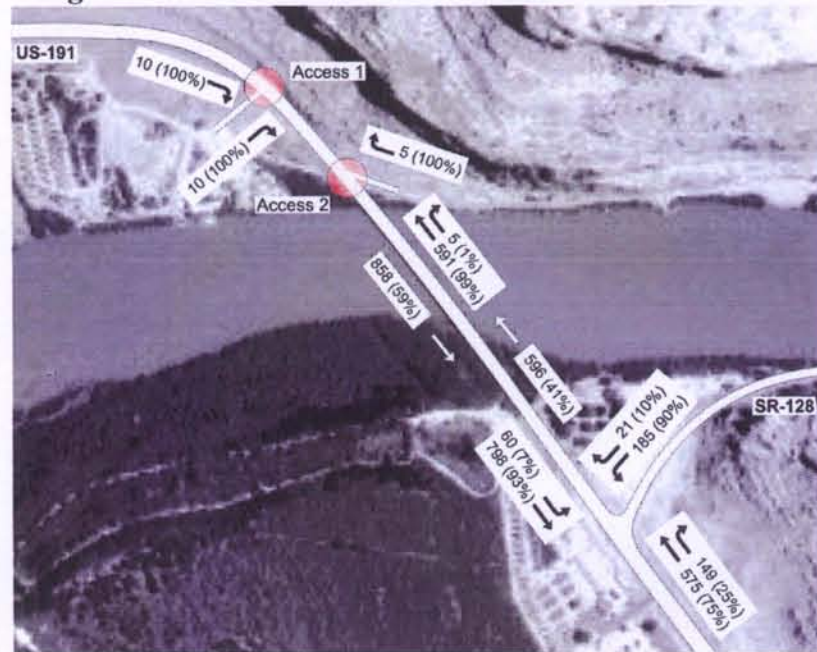
Table 14: Future Traffic Volumes for Analysis at US-191 and SR-128

Direction of Travel	Traffic Movement Volumes		
	Left	Thru	Right
South (US-191)	60 (7%)	798 (93%)	-
North (US-191)	-	575 (75%)	149 (25%)
West (SR-128)	185 (90%)	-	21 (10%)

Future projected volumes and turn movements are shown in Figure 15. Turn movement percentages are based on counts from *Sear-Brown Preliminary Traffic Report* and estimated in the design year by InterPlan. Also shown are intersections and driveways in the vicinity of the bridge. Access points with significant influence should be carefully considered. Level of service is not a problem at these intersections and accident history does not indicate problems. However, these uncontrolled driveways should be considered for right-in/right-out restrictions if accidents increase.

In addition, Synchro analysis concluded that the maximum queue length for southbound left-turning traffic from US-191 to SR-128 is 49 feet. Left-turn queues will not approach Colorado River Bridge infrastructure, which is more than 500 feet from the SR-128 intersection.

Figure 14: 2030 Traffic Volumes and Turn Movements



5. Recommendations

Based on considerations of existing traffic characteristics as well as projected future traffic volumes and the importance of US-191 as a regional facility, a four-lane cross-section for the Colorado River Bridge on US-191 is recommended. While a by-pass road was not extensively evaluated and an alignment for a potential by-pass facility was not reviewed, the recommended four-lane bridge cross-section would not change regardless of a by-pass road. If a by-pass road were to be created north and west of the existing Colorado River crossing, creating a need for an additional crossing, traffic volume reductions are expected to be less than 30 percent, still above the threshold for the need for additional travel lanes. Similarly, if a by-pass road were created south and east of the Colorado River crossing, by-passing town but with a single bridge, it is unclear that truck levels would be induced at all, and would certainly not grow to levels that would exceed the capacity of a four-lane bridge.

While the bridge represents the most expensive and potentially environmentally sensitive section of the study corridor, the study limits go beyond the bridge and other sections and issues need to be addressed. Details of the recommended cross-section along the entire study area are given below.

A. Cross-sections

i. On Bridge

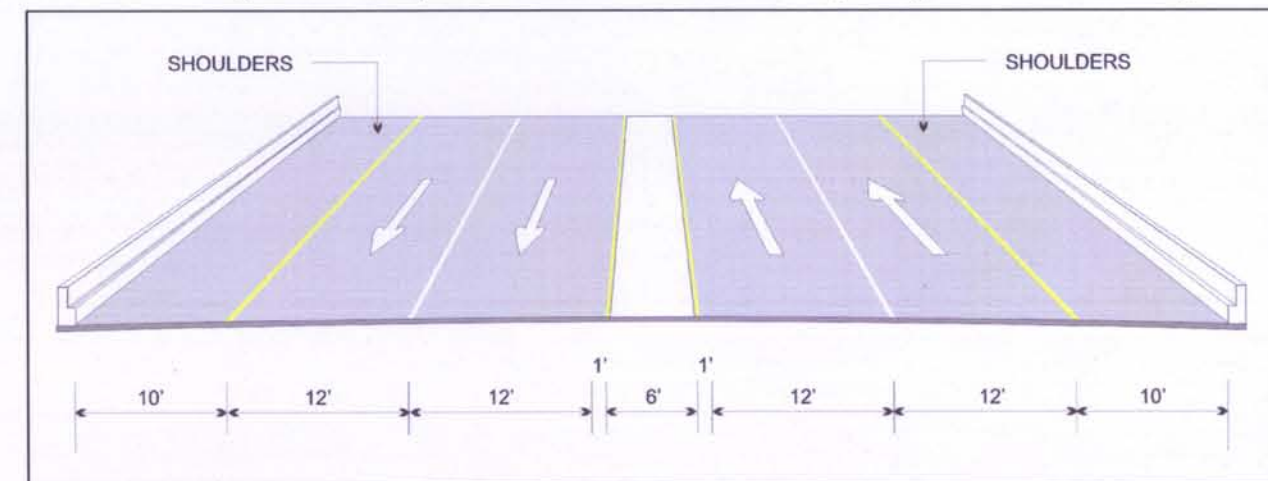
The recommended bridge cross-section includes four travel lanes, a center median, and sufficient shoulder width (8-12 feet) to allow for bicyclists, pedestrians, and disabled vehicles. AASHTO recommends a minimum shoulder width of eight feet. The center median should be between 10 and 14 feet wide. The median width should also consider left turn volumes and queues at driveways immediately north of the bridge at the boat ramp and south of the bridge at SR-128. While it appears as though a center turn lane over bridge would be desirable to allow exiting boat ramp traffic acceleration distance and entering SR-128 traffic deceleration distance, some thought should be given to the traffic-calming effect that the bridge may offer. As a constriction, the bridge presently serves as a clear demarcation between the high-speed

rural facility to the north and the approaching Main Street to the south. While widening of the bridge is desirable from a traffic flow standpoint, a continued demarcation of the rural and Main Street boundary should be preserved through median treatment, a "signature" bridge, or other measures.

ii. North of Bridge

Based on projected future traffic volume and truck percentage estimates, US-191 should be reconstructed as a four-lane facility with a center median. In this area, the highway should be designed as a high-speed road with, ideally, a depressed center median. The center median treatment should match the section through Moab Canyon but should also consider the growing number of access points closer to Moab. In addition, sufficient shoulder width should be provided for pedestrians, bicycles, and emergency stops. The proposed cross-section is shown in Figure 16.

Figure 15: Proposed Cross-Section of US-191, Bridge & North of Bridge

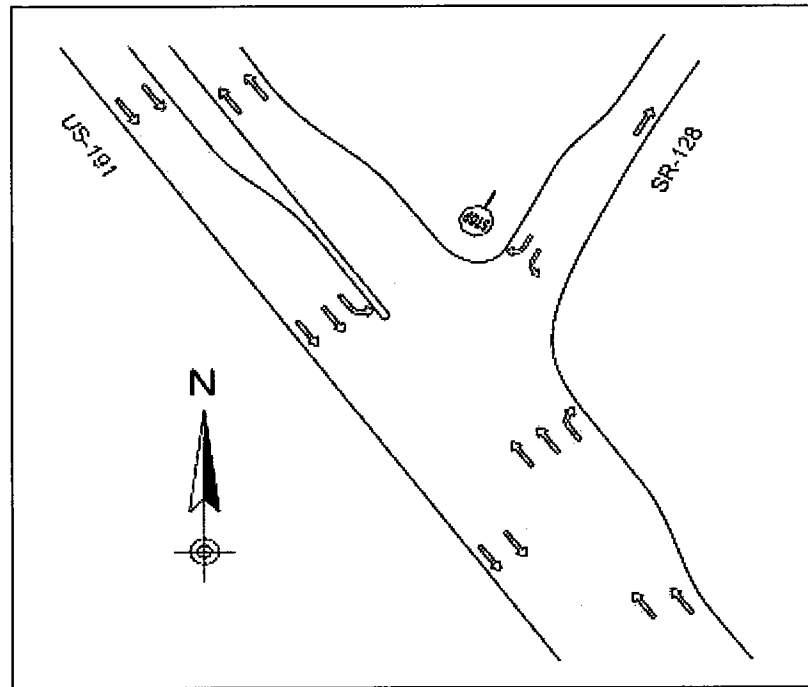


iii. South of Bridge

US-191 south of the Colorado River Bridge should be designed as a moderate speed (35 mph) urban facility with four travel lanes and a continuous center turn lane, essentially the same cross-section as shown above. As with the bridge itself, certain design features should signify an "arrival" from a rural cross-section to an urban section. In this section, additional landscaping or some type of gateway monument may be considered in the design to fit the context of Main Street Moab.

Traffic flow for the SR-128 intersection is also a consideration in this section. Figure 16 shows the proposed geometry of the US-191 and SR-128 intersection. Regardless of the median type over the bridge, a two-way center turn lane should be planned south of the SR-128 intersection.

Figure 16: Proposed Intersection Geometry, US-191 and SR-128



B. Pavement Width and Shoulders

The logical approach to determining appropriate lane and shoulder widths is to provide a width related to the traffic demands. Regardless of weather conditions, shoulders should be usable at all times. On high-volume highways, shoulders should generally be paved, but because of economic constraints, paved shoulders are not always practical. AASHTO recommends a minimum shoulder width of eight feet to provide for pavement support, wide vehicles, collision avoidance, and additional pavement width for bicyclists. Pedestrian and bicycle facilities are an important consideration in Moab City and Grand County. Shoulders should accommodate bicycle demand.

C. Median

A center turn lane could be provided across the bridge. The advantage of providing a center turn lane is that the bridge cross-section would be consistent with road cross-sections on the south side near Moab, and would facilitate driveway access. However, additional width will incur additional expense. As discussed earlier, queue lengths from left turning vehicles at SR-128 are not expected to be an issue on the bridge and so a center turn lane is not necessary from a traffic-queueing standpoint. The added cost of a full width turn lane versus a jersey barrier divided median should be evaluated across the bridge. South of the bridge, a two-way center turn lane appears desirable, but consideration of key landscaped median sections may be used to help establish an urban setting to slow traffic.

D. Side Treatment

Sidewalks and related treatments outside of the roadway width have not been explicitly examined in this study. Grand County and Moab City are proceeding with plans for a parallel bridge north of the existing bridge to serve non-motorized needs. Other plans are also advancing for a comprehensive series of bicycle and pedestrian amenities between Arches Park and Moab. The bridge cross-section should complement these non-motorized transportation plans, but it is unclear whether sidewalks or some other type of non-motorized cross section is needed across the bridge. Future design should coordinate with community leaders and help enhance the recreational nature of the area.

E. Phasing

From a traffic and safety standpoint, the entire study area represents a traffic bottleneck. Funding and environmental considerations of the bridge are probably the most significant reasons to delay immediate improvements, and accident data does not suggest any urgency from a safety standpoint. Similarly, no sections of the corridor stand out as deserving higher priority than others. Urban growth between the Moab City limits and SR-128 appears to have intensified accident issues. Accident data should be monitored in this area and a short-term consideration of a center turn lane may provide some relief of growing problems.

APPENDIX:
Utah Department of Transportation
Operational Safety Report



State of Utah

OLIVER S. WALKER
Governor

GAYLE McKEACHIN
Lieutenant Governor

DEPARTMENT OF TRANSPORTATION

JOHN R. NIORD, P.E.
Executive Director
CARLOS M. BRACERAS, P.E.
Deputy Director

April 23, 2004

Matt Riffkin, P.E.
InterPlan Co.
64 East 6400 South, Suite 215
Murray, Utah 84107

Re: Draft Operational Safety Report
Project No. BRF-0191(23)128; Colorado River Bridge Corridor Study near
Moab; RP 126.0 to RP 132.0.

Dear Mr. Riffkin:

We have evaluated the accident history for the subject bridge location near Moab for the
three-year period of 2000 through 2002, with the following results:

OTHER PRINCIPAL ARTERIAL		ACTUAL			TOTAL/AVG	EXPECTED
		2000	2001	2002		
Number of Accidents		13	14	22	49 / 16.3	
Accident Rate		0.89	0.96	1.49	1.13	1.96
Severity		1.38	1.71	1.77	1.62	1.70
Single Vehicle Acc.	42.9%				21	
Right Angle Accident	16.3%				8	
Rear End Accident	14.3%				7	

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Calvin Rampton Complex, 4501 South 2700 West, Salt Lake City, Utah 84119-5998
telephone 801-965-4000 • facsimile 801-965-4338 • www.udot.utah.gov

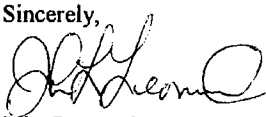
Utah!
Where ideas connect

Accident data indicates that both the accident rate and severity of this section are lower than the expected. The predominant accident types are listed on the table above. The breakdown of single vehicle accidents is as follows:

	<u>ACC. TYPE</u>	<u>NUMBER</u>	<u>% OF SINGLE VEH. ACC.</u>
1.	Wild Animal Related	12	57.1
2.	Overturned in Roadway	2	9.5
3.	Other Object	1	4.8
4.	Ran Off Road Right	5	23.8
5.	Bicycle Related	1	4.8
		<u>TOTAL=21</u>	

All of the wild animal related accidents occurred between accum- MP 127.0 and 128.0; right angle and rear end accidents were generally scattered throughout the length of this corridor study; however, a few of these accidents occurred at the intersections of 100 North and 400 North in Moab. No other clusters of accidents were observed.

Source documents are available at the Division of Traffic and Safety for additional analysis. If questions arise, please call me at 965-4045.

Sincerely,

John Leonard, P.E.
Operations Engineer

JLL/EG/ar

cc: Robert Hull Eric Cheng Zeke Gonzalez
John Leonard Roland Stanger, FHWA Kim Manwill, R-4
Troy Torgersen, R-4